Cover Crops, Herbicides, and Dealing with Herbicide-Resistant Weeds

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Herbicide considerations when establishing cover crops and when it is time to terminate

Dr. Bill Curran
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Part 1

- **Impact of herbicides on cover crop establishment**

Residual Herbicides

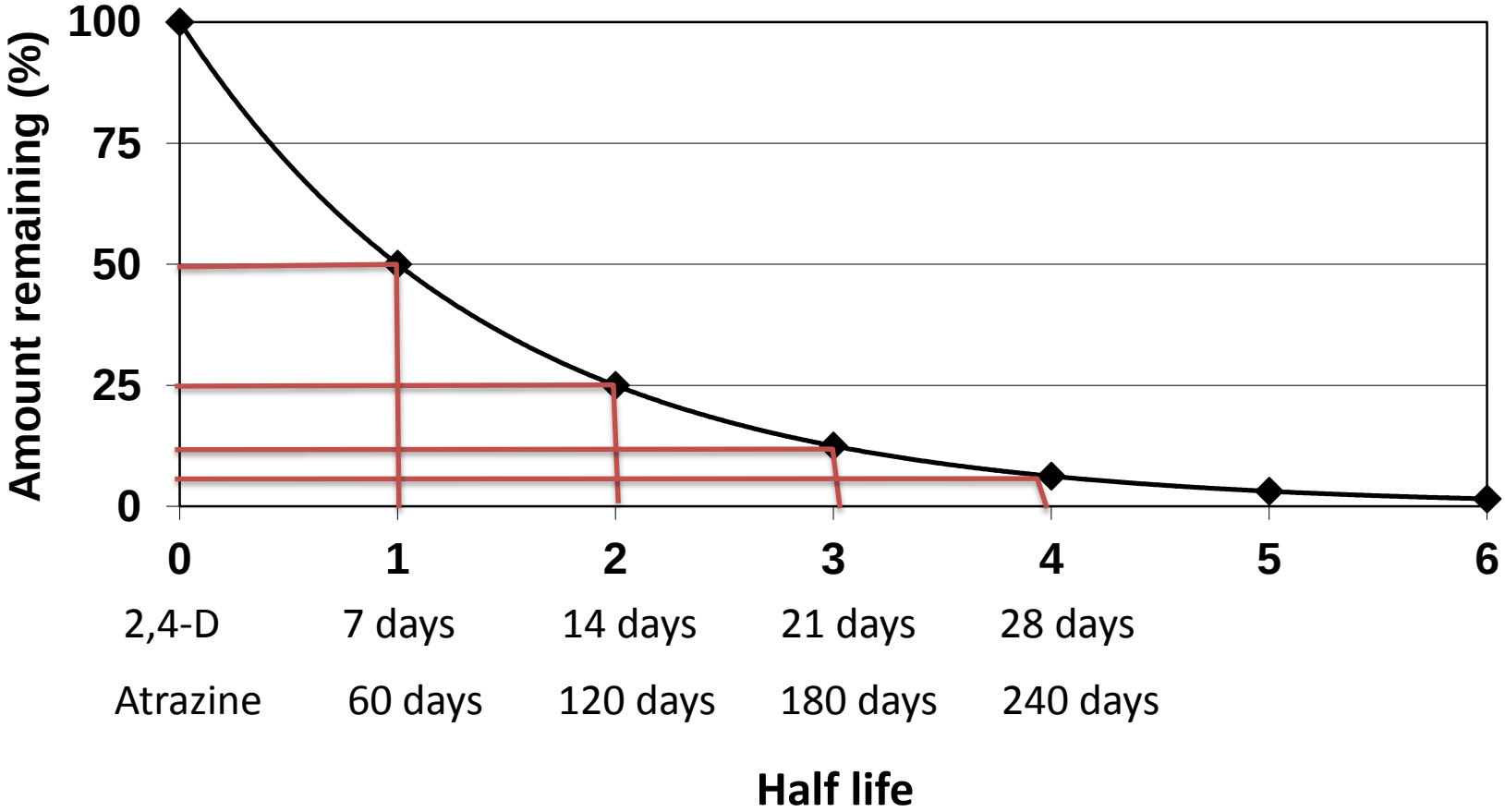
- Used in many of our major crops
- Usually soil applied – sometimes POST
- Generally provide 8 to 12 weeks of weed control
- Half-life too short - lack of residual weed control (performance reduced)
- Half life too long - carryover to following crop
  - Very important consideration for some crops and especially those established in late summer/fall
  - Particular consideration if interseeding cover crops in early summer

Carryover Injury to Subsequent Crops Depends On:

- Herbicide **persistence** in soil
  - How long does it last?
  - Herbicide half-life gives us some indication
- Rotational crop **sensitivity/susceptibility**
  - How sensitive are rotational crops - legumes, radish/mustards, grasses
- Persistent herbicides that aren't very active and short-lived herbicides that are very active don't really matter

#1 Herbicide Persistence

- **Half-life: the amount of time needed to degrade half of the herbicide present**

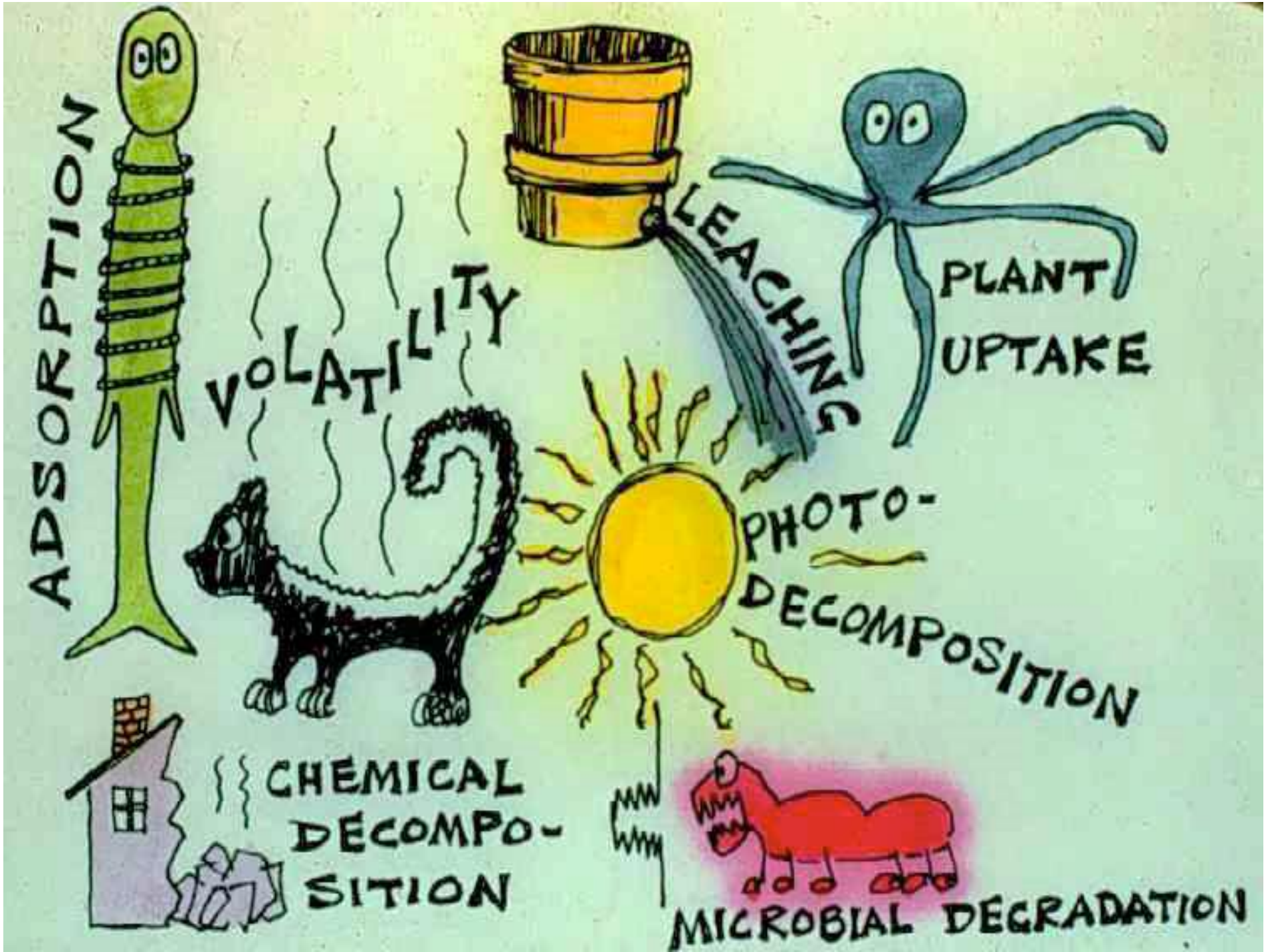


Herbicide half-life
General Rule

- Short - < 30 days
- Intermediate - 30 –120 days
- Long - > 120 days

Common Herbicide's Half-Life

- 2,4-D – 7 days
- Atrazine – 15-90 (60) days
- Callisto – 5-50 days
- Dicamba – 14 days
- Dual Mag – 15-50 (35) days
- Impact – 14 days
- Pursuit – 60 – 90 (75) days
- Resolve – 7 days


ADSORPTION
VOLATILITY
LEACHING
PLANT UPTAKE
PHOTO-DECOMPOSITION
CHEMICAL DECOMPO-SITION
MICROBIAL DEGRADATION

Geographic/Management Factors That Influence Dissipation Rate

- Soil texture and pH – heavy soil and high pH = last longer
- Consider drought – last longer – long half-life becomes longer
- Application rate - full vs. reduced rates
- PRE vs. POST - time between application and next crop
- Tillage system
  - No-till vs. tilled systems – tillage can dilute residues
- Herbicide combinations – two or more with longer half-lives increases injury potential

Corn Herbicide Categories

<u>≥ 4 months</u>

- Atrazine*
- Balance
- Callisto
- Corvus
- Permit*
- Simazine*
- Stinger/Hornet
- Python

<u>2-4 months</u>

- Accent*
- Capreno
- Dual
- Harness/Degree
- Impact/Armezon
- Metribuzin
- Outlook
- Prowl
- Zidua

<u>≤ 2 months</u>

- 2,4-D
- Clarity/Banvel
- Glyphosate
- Liberty
- Harmony
- Resolve*
- Sharpen

*last longer when soil pH > 6.8

Soybean Herbicide Categories

<u>≥ 4 months</u>

- Authority
- Classic (Canopy etc)*
- FirstRate
- Pursuit
- Python
- Reflex/Flexstar
- Scepter

<u>2-4 moths</u>

- Assure/Targa
- Dual
- Raptor
- Metribuzin
- Outlook
- Prowl
- Valor
- Zidua

<u>≤ 2 months</u>

- 2,4-D
- Glyphosate
- Liberty
- Harmony
- Select
- Sharpen

*Last longer when soil pH > 6.8

Carryover Injury to Subsequent Crops Depends On:

- Herbicide **persistence** in soil
  - How long does it last?
  - Herbicide half-life gives us some indication
- Rotational crop **sensitivity/susceptibility**
  - How sensitive are rotational crops - legumes, radish/mustards, grasses
- Persistent herbicides that aren't very active and short-lived herbicides that are very active don't really matter

#2 Crop sensitivity

- Atrazine: alfalfa = clovers > radish = ryegrass/timothy > hairy vetch = pea > oats > wheat = barley = rye
- Mesotrione: clovers = alfalfa > radish > hairy vetch > pea >>>>>> grasses

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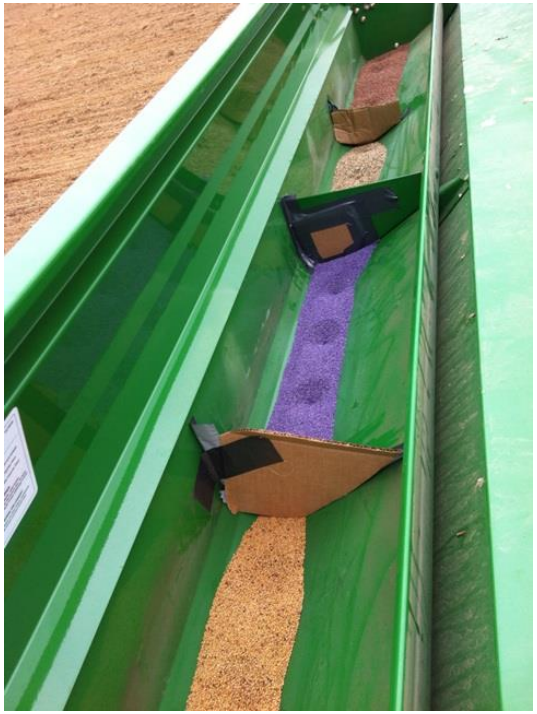
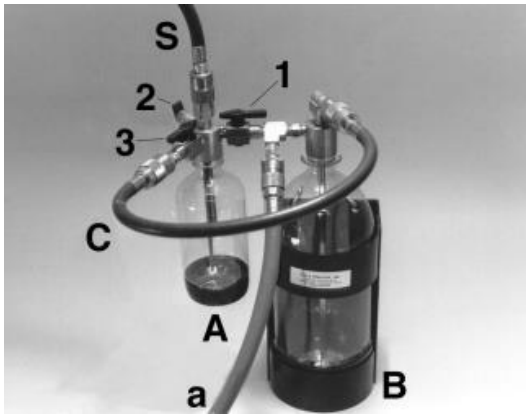
- Chlorimuron: clovers = alfalfa > radish > hairy vetch > pea > sorghum > corn >>> cool season grasses
- Imazethapyr: radish > sorghum > hairy vetch > pea > clovers > alfalfa > corn >>> cool season grasses

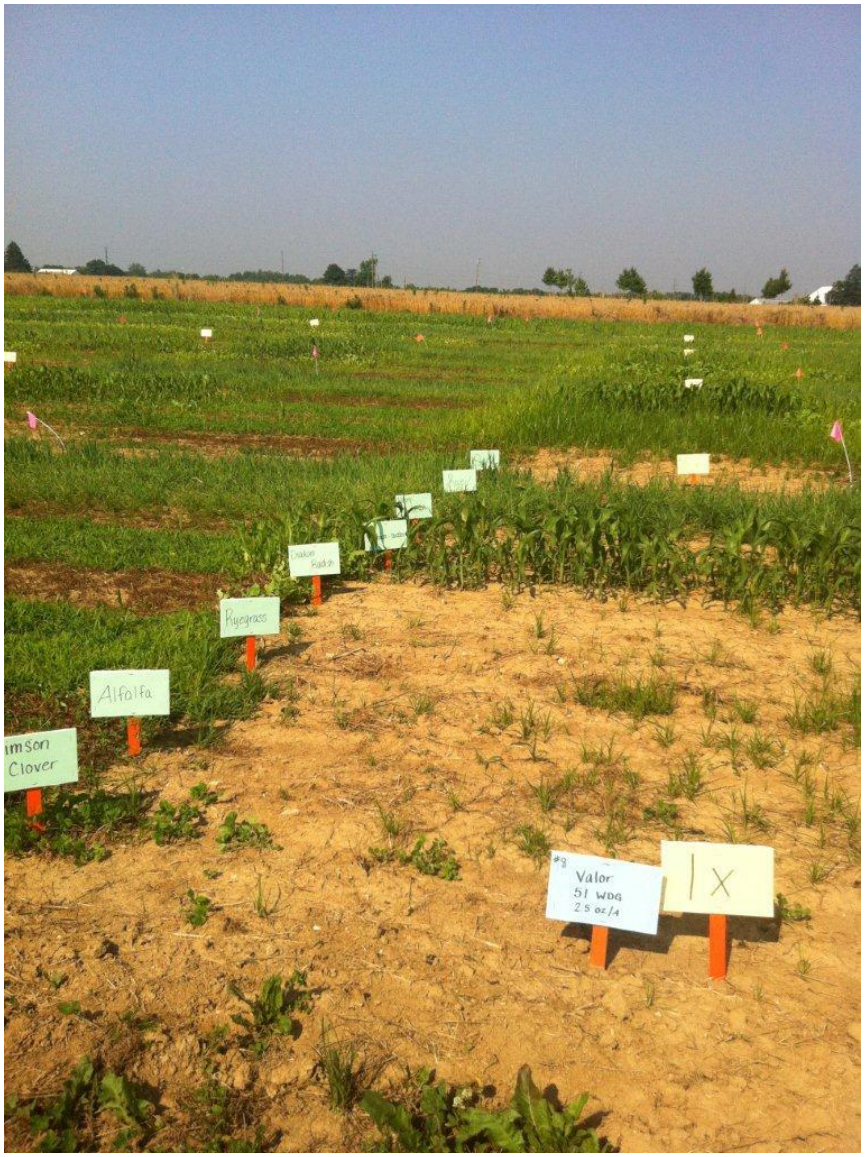
Herbicide selectivity and persistence demonstration



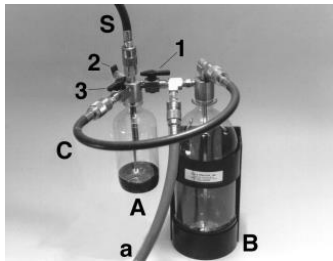


1 & 2 L bottles – Weed Spray System Equipment

Herbicide selectivity/persistence demo

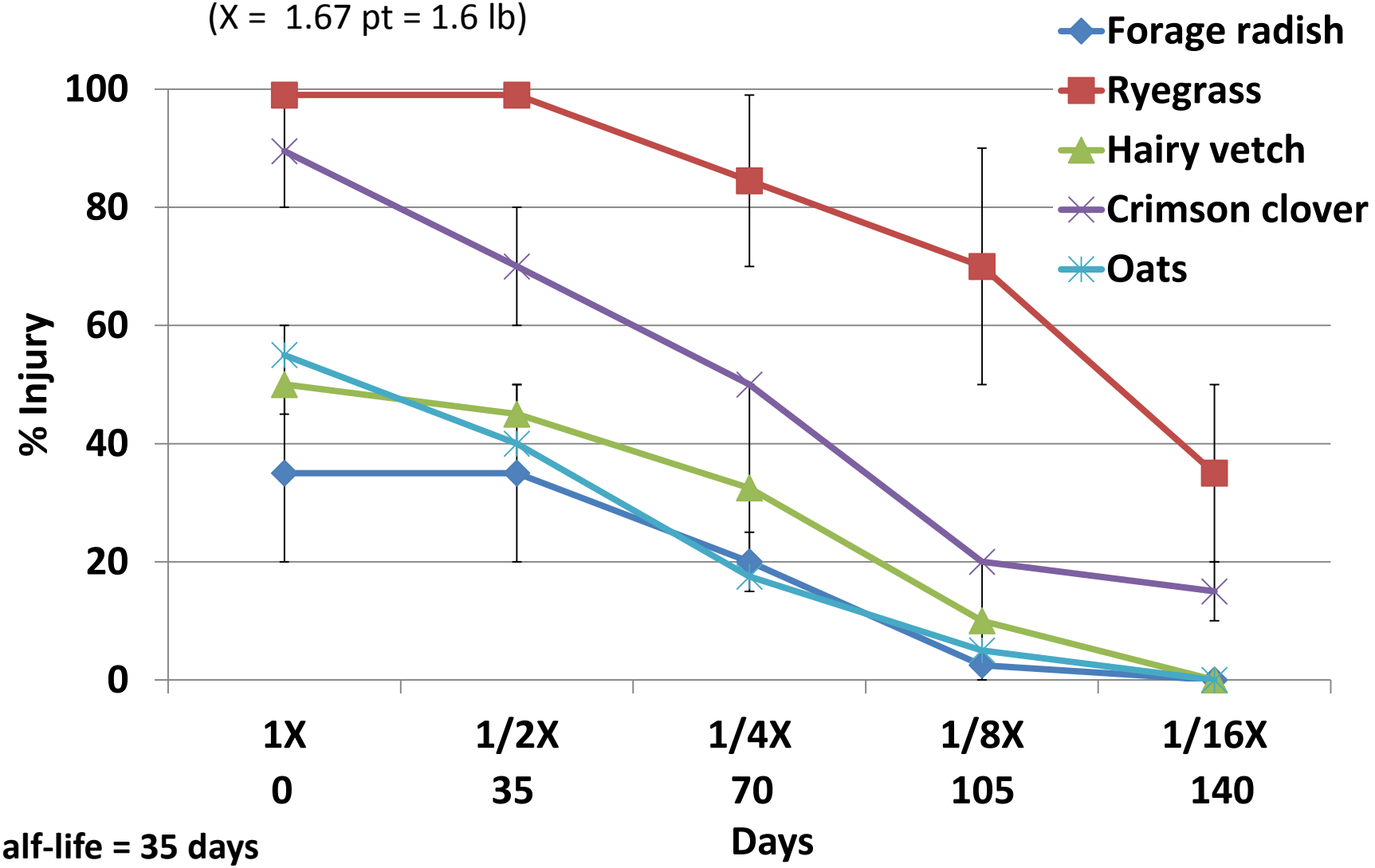


- Applied herbicides and seeded crops within a day - 6 to 8 species – legumes, grasses, brassicas
- Log sprayer – allows relatively precise dilutions – 100% (1X), 50% (1/2X), 25% (1/4X), 12.5% (1/8X), 6.25% (1/16X)
- Visually evaluated about 4 weeks after seeding (0-100% scale) and used as an educational tool during field day
- Herbicide dilution used as a proxy for half-life
- Half life values taken from the literature



Effect of decreasing Dual Mag rate on cover crop injury (ave. over two years)

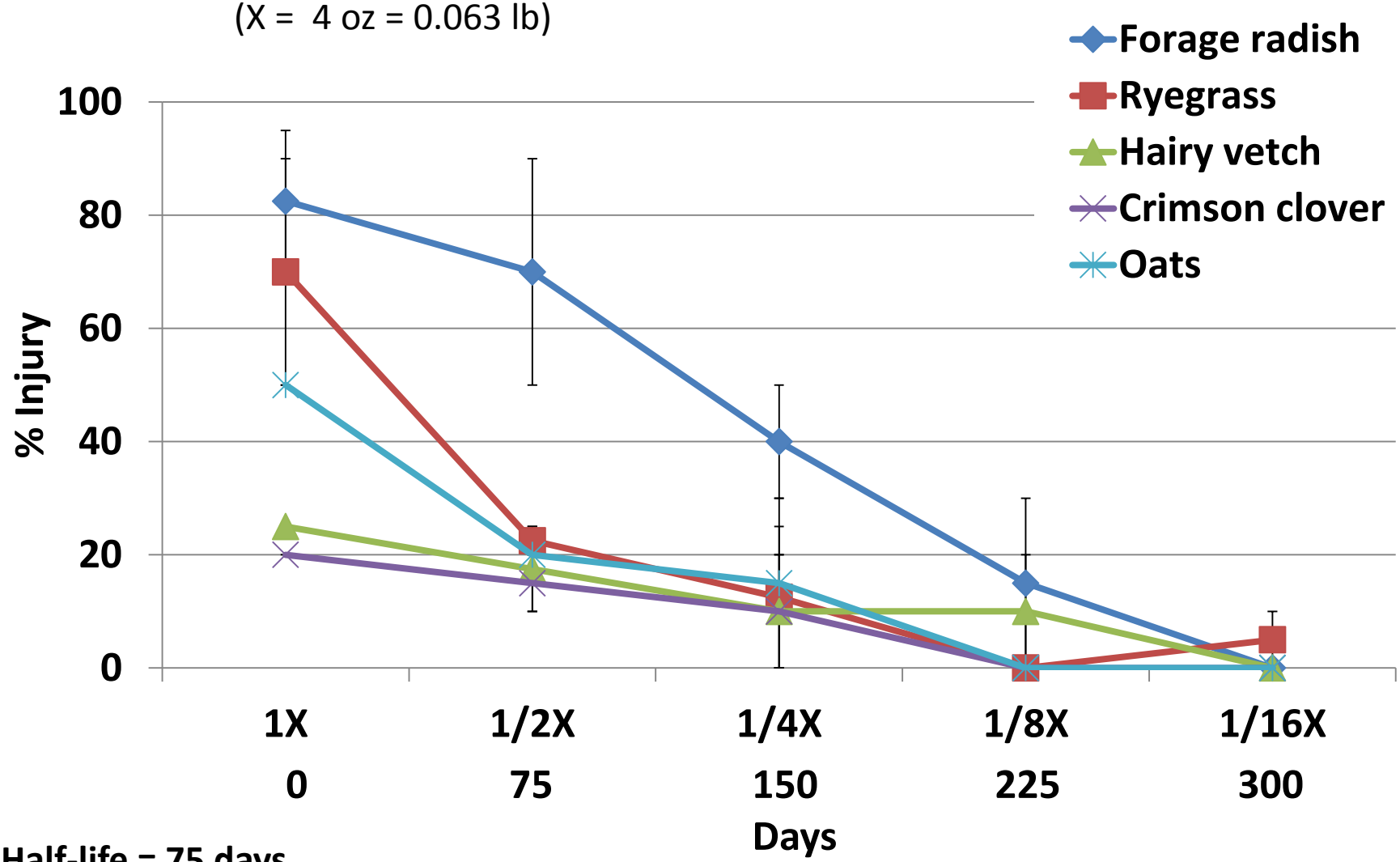
(X = 1.67 pt = 1.6 lb)



Half-life = 35 days

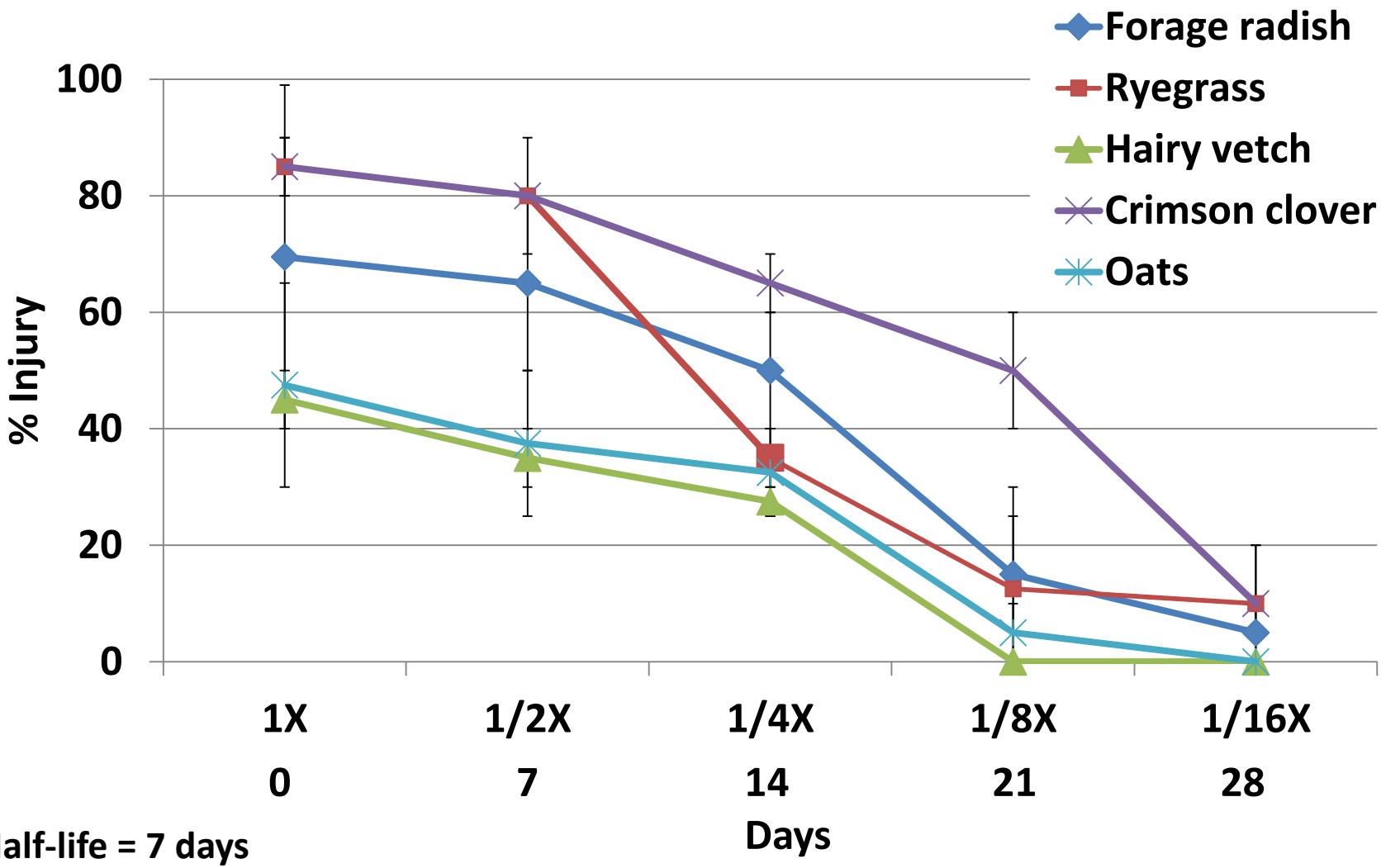
Effect of decreasing Pursuit rate on cover crop injury (ave. over two years)

(X = 4 oz = 0.063 lb)



Half-life = 75 days

Effect of decreasing Resolve rate on cover crop injury (ave. over two years)



Half-life = 7 days

Planning Ahead – <u>know your herbicide residual</u>

- Check a current Management Guide recrop tables
- Check label for use restrictions – recrop tables
  - Consider particularly sensitive crops – alfalfa, clovers, canola, ryegrass, others
- Look for Half-Life Information

From 2017 Mid-Atlantic Field Crop Weed Management Guide

Table 1-6. Herbicide rotation restrictions for cash crops.

The information listed in this rotation restriction table is our interpretation of label statements or a "best guess" estimate. Consult the label if two or more of these materials are applied during the same season. Herbicide labels are constantly changing; therefore, this list is not a substitute for the most recent herbicide label.

AH = after harvest
B = bioassay of soil recommended before planting
NI = no information
NR = no restrictions
NY = next year
SY = second year following application

	Rotation Crops (months after application)																									
Trade Name	Alfalfa	Cabbage	Clover	Cotton	Cucumber	Field Corn	Grain Sorghum	Lima Bean	Muskmelon	Onion	Peanut	Peas	Pepper	Pumpkin	Snap Bean	Soybean	Spring Oat	Squash	Sweet Corn	Tobacco	Tomato	Watermelon	White Potato	Winter Barley	Winter Rye	Winter Wheat
2,4-D	AH	3	AH	1	AH	NR	AH	3	3	3	1	AH	AH	AH	AH	0.25–1[1]	AH	3	NR	NY	AH	3	AH	AH	AH	AH
Acuron	18	18	18	10	18	NR	10	18	18	18	10	18	18	18	18	10	18	18	NR	18	18	18	10	4	4	4
Atrazine	SY	SY	SY	NY	SY	NR	NR	SY	SY	SY	NY	SY	SY	SY	SY	NY	SY	SY	NR	SY	SY	SY	SY	NY	NY	NY
Balance Flexx/Pro	10	18	18	10	18	NR	6	18	18	18	11	18	18	18	18	6	18	18	6	18	18	18	6	6	4	4
Callisto	10	18	18	10	18	NR	NR	18	18	18	10	18	18	18	18	10	NR	18	NR	10	18	18	10	4	4	4

Callisto®Label

- Immediate – corn, asparagus, cranberry, millet, grasses grown for seed, oats, and sorghum
- 120 days – small grains
- 10 mo. – alfalfa, canola, cotton, potatoes, soybean, sunflower, tobacco
- 18 mo. – sugar beets, dry beans, peas, cucurbits, red clover, and all other rotational crops

From 2017 Mid-Atlantic Field Crop Weed Management Guide

Table 1-6. Corn herbicide half-lives and their potential to injure fall-established cover crops.

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Trade Name	Common Name	Normal Rate/Acre	Half-life (days)[1]	Fall-established Cover Crops		Other
				OK to plant	Concern for	
2,4-D 4S	2,4-D	1–2 pt	7	All grasses	Wait 30 days before planting sensitive broadleaves	Amine formulations more water soluble and can leach into seed zone
Atrazine 4L	atrazine	1–2 qt	15–90	Sorghum species	Cereals, ryegrass, legumes, and mustards	More persistent in high pH soils (> 7); rates < 1 lb/acre can allow more flexibility; half-life in PA probably closer to 30
Balance Pro 4L/ Balance Flexx 2L (Prequel 45WG also contains isoxaflutole)	isoxaflutole	3 fl oz 6 fl oz	50–120	Fall cereals grains	Cereals, ryegrass, legumes, and mustards	15 inches of cumulative precipitation required from application to planting rotation crops except soybean, barely, wheat, sorghum, and sunflower
Callisto (includes Acuron, Halex GT, Instigate, Lexar, Lumax, Resicore, Zemax, etc.)	mesotrione	3–6 fl oz	10–50	All grasses	Small-seeded legumes, mustards	Sequential applications (PRE fb POST) increase the potential for injury

General guidelines

- Corn herbicides
  - Atrazine or simazine at < 1 lb/A can allow cereal grain establishment.
    - < 0.75 lb/A may allow for most legume cover crops, mustards, and annual ryegrass.
  - Mesotrione (Callisto, Accuron, etc. is problematic for legumes and mustards like canola and forage radish.
  - Isoxaflutole (Balance, Corvus, Prelude) – legumes and mustards mostly.
  - Clopyralid (Stinger and a component of Hornet, SureStart, Resicore) could also affect these small seeded broadleaves.

Mesotrione-Containing Corn Products

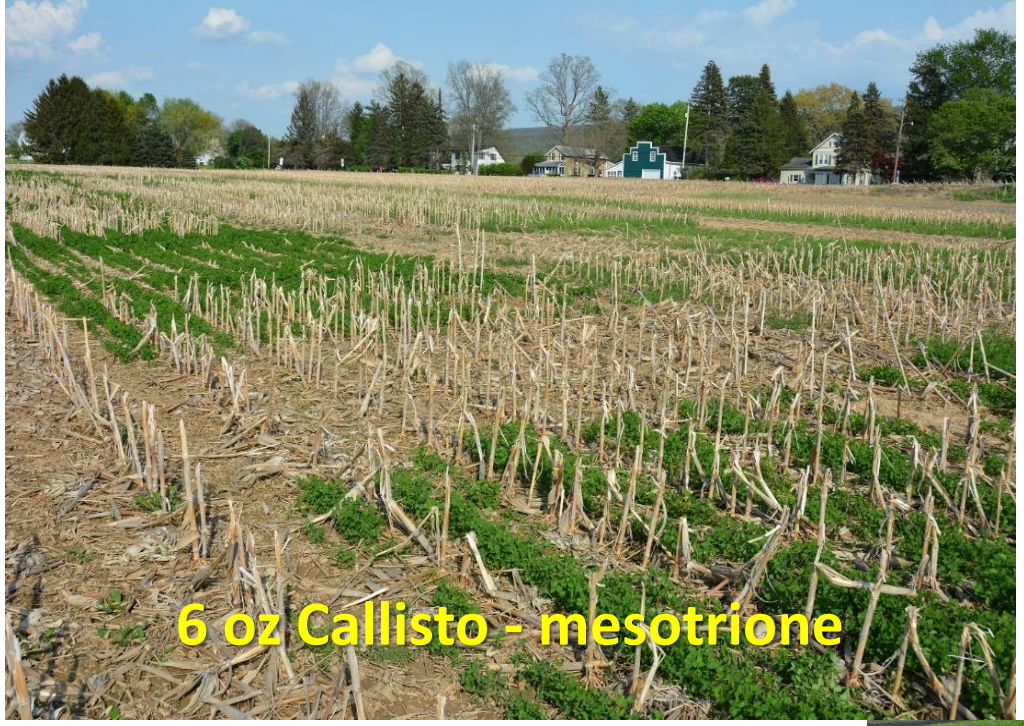
- Callisto
- Acuron
- Acuron Flexi
- Callisto GT
- Callisto Xtra
- Halex GT
- Harness MAX
- Instigate
- Lexar
- Lumax
- Realm Q
- Resicore
- Revulin
- Solstice
- Zemax

General guidelines

- Soybean herbicides
  - Chlorimuron (Classic, etc.), imazethapyr (Pursuit), and fomesafen (Reflex etc.) could be a problem for fall seeded legume or mustard covers - cereal grains OK.
- Wheat herbicides
  - Generally not a problem, except for companion or relay cropping - If you can double-crop soybean, should be OK

PennState

Tolerance of interseeded annual ryegrass and red clover cover crops to residual herbicides in mid-Atlantic corn production. Wallace et al. *Weed Technol.*



Interseeding cover crops requires much more attention

Grass Herbicides: Risk of Interseeded Cover Crop Injury

Potential Biomass Reduction (%) Low (<15%) Mod (15-30%) High (>30%)

Grass Herbicides	Product Rate	Label Rate	Appl Timing	Annual Ryegrass	Red Clover	AR/RC Mixture
Chloroacetamides (15)						
Dual II Mag 7.64 EC	1.67 pt	1X	PRE	High	Mod	High
Zidua 85 WG	2.5 oz	1X	PRE	High	Mod	High
Outlook 6 EC	½ pt	½X	PRE	Low	Low	Low
Outlook 6 EC	1 pt	1X	PRE	Mod	Low	Mod
Harness 7 EC	1 pt	½X	PRE	Low	Low	Low
Harness 7 EC	2 pt	1X	PRE	Mod	Low	Mod
Dinitroanilines (3)						
Prowl H2O 3.8 CS	1.5	½X	PRE	Low	Low	Low
Prowl H2O 3.8 CS	3 pt	1X	PRE	High	Mod	High

Potential High Risk Products

~ containing **Dual**: Acuron, Bicep/Cinch, Camix, Expert, Halex GT, Lumax/Lexar, Zemax

~ containing **Zidua**: Anthem

https://extension.psu.edu/evaluation-of-residual-herbicides-for-interseeding-in-corn

Broadleaf Herbicides: Risk of Interseeded Cover Crop Injury

Potential Biomass Reduction (%) Low (<15%) Mod (15-30%) High (>30%)

Broadleaf Herbicides	Product Rate	Label Rate	Appl Timing	Annual Ryegrass	Red Clover	AR/RC Mixture
Sulfonylurea (2)						
Resolve 25 DF	0.5 oz	½X	PRE			
Resolve 25 DF	1 oz	1X	PRE			
Triazines (5)						
Atrazine	1 pt	½X	PRE			
Atrazine	2 pt	1X	PRE			
Atrazine	3 pt	1½X	PRE			
Metribuzin	4 oz	1X	PRE			
PPOs (14)						
Sharpen	1.5 fl oz	½X	PRE			
Sharpen	3 fl oz	1X	PRE			
HPPDs (27)						
Balance Flex 2 SC	5.3 fl oz	1X	PRE			
Callisto 4 SC	5.4 fl oz	1X	PRE			

Potential High Risk Products

~ containing **Callisto**: Acuron, Camix, Halex GT, Instigate, Lumax/Lexar, Realm Q, Revulin, Resicore, Zemax

~ containing **>1.5 lb atrazine at std rate**: Expert, Bicep/Cinch Magnum, Harness Xtra

Summary – on silt loam soils in the Mid-Atlantic

If Interseeding Annual Ryegrass:

- Avoid programs w/ Dual, Zidua, Prowl
- Use programs based on Harness or Outlook (G15)
- May tank mix Callisto

If Interseeding Legumes:

- Avoid programs w/ Callisto, Balance
- Use programs based on Harness or Outlook (G15)
- May tank mix Dual or Zidua

If Interseeding Mixtures:

- Avoid programs w/ Callisto, Balance, Dual, Zidua, Prowl
- Use programs based on Harness or Outlook
- Use low rates of atrazine (1 – 2 pts/ac) in programs

Part 2

- **Impact of herbicide selection and timing on cover crop termination**

Herbicide Considerations

- Selecting herbicides that are effective on both cover crops and weeds
  - What if you have emerged glyphosate-resistant horseweed/marestail or waterhemp
- What about residual herbicides?
  - Concerns for spray coverage?
  - Separate application?
- Concern for crop injury with some active's
  - May require delayed planting after application – what about planting green?

Herbicide Considerations

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Primary Burndown Herbicides

- Glyphosate (Roundup) – Broadleaves and grasses
- Paraquat (Gramoxone)– Broadleaves and grasses
- Glufosinate (Liberty) – Broadleaves and grasses (limited utility)
- PGR’s - 2,4-D and Dicamba (Banvel) and maybe clopyralid (Stinger) – Broadleaves only

Table 2-4. Effectiveness of herbicides for control of common cash or cover crops in spring before corn establishment.

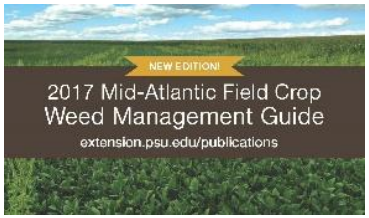
Control ratings:
10 = 95–100%
9 = 85–95%
8 = 75–85%
7 = 65–75%
6 = 55–65%
N = less than 55%

Herbicide	Rate (lb/acre)[1]	Alfalfa[2]	Bluegrass/Timothy[2]	Bromegrass/ Orchardgrass/Fescue[2]	Clover, Crimson	Clover, Red[2]	Clover, White[2]	Mustards/Radish/ Rapeseed	Ryegrass, Annual	Rye, Cereal	Wheat, Winter	Vetch, Hairy
2,4-D ester	0.5	7+	N	N	7	8	6	8	N	N	N	**9**
	1	8	N	N	8	**9**	7	**9**	N	N	N	**10**
2,4-D ester + dicamba	0.5 + 0.5	**9+**	N	N	**8+**	**9**	**9**	8	N	N	N	**10**
Atrazine	1	N	6	6	6	6	6	6	6	6	6	7
	2	6	7	7	7	7	7	7	7	7	7	8
Clopyralid	0.25	**8+**	N	N	8	**9**	**9**	N	N	N	N	**9**
Dicamba	0.5	**9**	N	N	8	**9**	**9**	7	N	N	N	**9**
Glyphosate	0.75	6	**9**	8	8	7	6	7+	8	**9**	**9**	7
	1.5	7	**9+**	**8+**	**8+**	7+	7	**8+**	**9**	**9**	**9**	8
Glyphosate + 2,4-D ester or	0.75 + 0.5	**8+**	**9**	8	**9**	8	8	**9**	8	**9**	**9**	**10**
dicamba		**9**	**9**	8	**9**	**9**	**9**	8	8	**9**	**9**	**10**

Table 2-3. Relative effectiveness of burndown treatments for control of weeds in no-till corn.

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Treatments are rated only for control of vegetation existing at the time of application.

Weed control rating:
10 = 95–100%
9 = 85–95%
8 = 75–85%
7 = 65–75
6 = 55–65%
N = less than 55% or no control
— = not applicable or no local data available

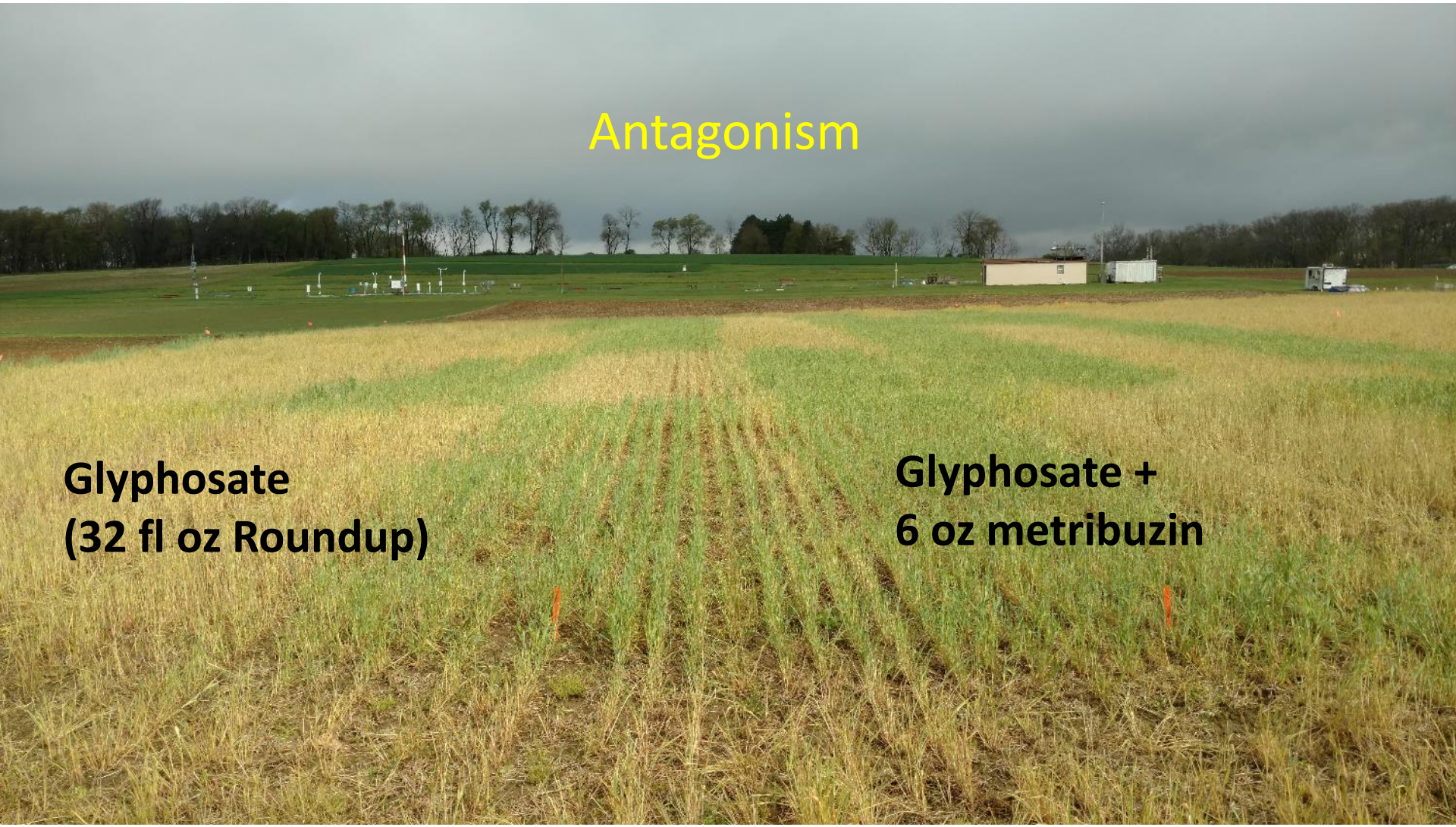


Herbicide[1]	Site of Action Number	Brome, Downy	Burdock, Common	Chickweed	Dandelion	Dock, Curly	Dogbane, Hemp; Dewberry; Milkweed; etc.	Evening Primrose, Cutleaf	Fleabanes, Annual	Foxtail spp.	Garlic, Wild	Geranium, Carolina	Groundsel, Common[2]	Henbit/Deadnettle	Horseweed/Marestail[3]	Lambsquarters	Mustard spp.	Quackgrass Sod	Ragweed, Common	Smartweed	Thistle, Canada	Violet, Field/Pansy
2,4-D (spring-applied) (1 qt)	4	N	7	6	8	7	N	9	6	N	7	—	6	N	8+	9	9	N	9	7	8	6
2,4-D + dicamba (spring-applied)	4/4	N	8	8	8	7+	6	9	8	N	7	7+	7	6	9	9	9	N	9	9	8+	7
Atrazine	5	7	6	8	N	6	N	7	7+	7	N	9	9	8	8	N	8	8	9	9	6	8
Atrazine + 2,4-D	5/4	7	7+	8	9	7	N	9	7+	7	7	9	9	8	9	9	9	7	9	9	8+	8
Autumn Super + 2,4-D (fall-applied)	2/4	N	9	9[4]	9	7	N	9	8	N	—	—	8	9	9	—	9	N	—	—	6	6
Balance/Corvus/Prequel	27/(2)	N	7	8	6	N	N	—	7	6	—	—	8	7+	7	7	8	N	7	6	6	6
Glyphosate (fall-applied)[5]	9	9	8+	9	9	7	8+	7	8	—	9	8	9	8	8+[6]	—	9	9	—	—	9	7
Glyphosate (spring-applied)[5]	9	9	7	9	6	6	7	6	7+	9+	8	7	9	6	8	9	9	8	9	7	8	6
Glyphosate + 2,4-D or dicamba (fall-applied)	9/4	9	9+	9	9	7	9	9+	9[6]	—	9	8	9	8+[6]	9+[6]	—	9[6]	9	—	—	9+	7

Glyphosate

GROUP	9	HERBICIDE

- Good on all cereal grains and most grasses
- Rates range from 0.375 – 1.5 lb ae/acre depending on species and growth stage
- Fair to good on many broadleaves
  - Weak on legumes
- Apply at 5 to 40 GPA (lower rate for low volume applications)
- Less mature annuals easier to control
- Glyphosate + NIS + AMS most effective
  - Tank-mixtures may reduce activity (particularly higher rate clay-based herbicides). Avoid tank-mixing with certain foliar/liquid fertilizers



12 days after application

22 days after application

Sometimes avoid certain tank-mixes or increase the glyphosate rate and apply under optimum conditions

Corn – atrazine/simazine

- Acuron
- Bicep
- Degree Xtra
- FulTime
- Keystone
- Lumax/Lexar
- Princep

Soybean - metribuzin

- Authority MTZ
- Boundary
- Canopy
- Trivence

Paraquat

GROUP 22 HERBICIDE

- Currently sold as Gramoxone
- Apply 0.5 to 1.0 lb/acre (2 - 4 pt) based on weed size (1-6 inches)
- Apply in a minimum of 10 GPA water (general rule)
- Use flat fan nozzle tips
- Include appropriate surfactant (NIS or COC)
- Do not spray in suspension-type fertilizers
- *Tank-mix with PSII (Group 5) herbicides to increase control (atrazine, metribuzin, etc.)*
- *"For grass cover crops, apply prior to tillering or after boot stage. Treatments made between tillering and boot stage may not provide complete control"*

RESTRICTED USE PESTICIDE
DUE TO ACUTE TOXICITY

Gramoxone
+ metribuzin
Gramoxone
11 DAA

Photo taken May 18

Herbicide Considerations

- Selecting herbicides that are effective on both cover crops and weeds
  - What if you have emerged resistant horseweed or pigweeds
- What about residual herbicides?
  - Concerns for spray coverage?
  - Requires separate application?
- Concern for crop injury with some active's
  - May require delayed planting after application – negates the planting green concept

05 29 2014 12 08

Cover crop termination timing effect on soil moisture, soil temperature, and slug populations in PA no-till corn and soybeans

PLANTING GREEN

Heidi Myer, Heather Karsten, John Tooker, Bill Curran, Sjoerd Duiker
Ron Hoover, Steve Groff, Jim Harbach, Joel Myers, Gerard Troisi

NORTHEAST SARE
Sustainable Agriculture Research & Education
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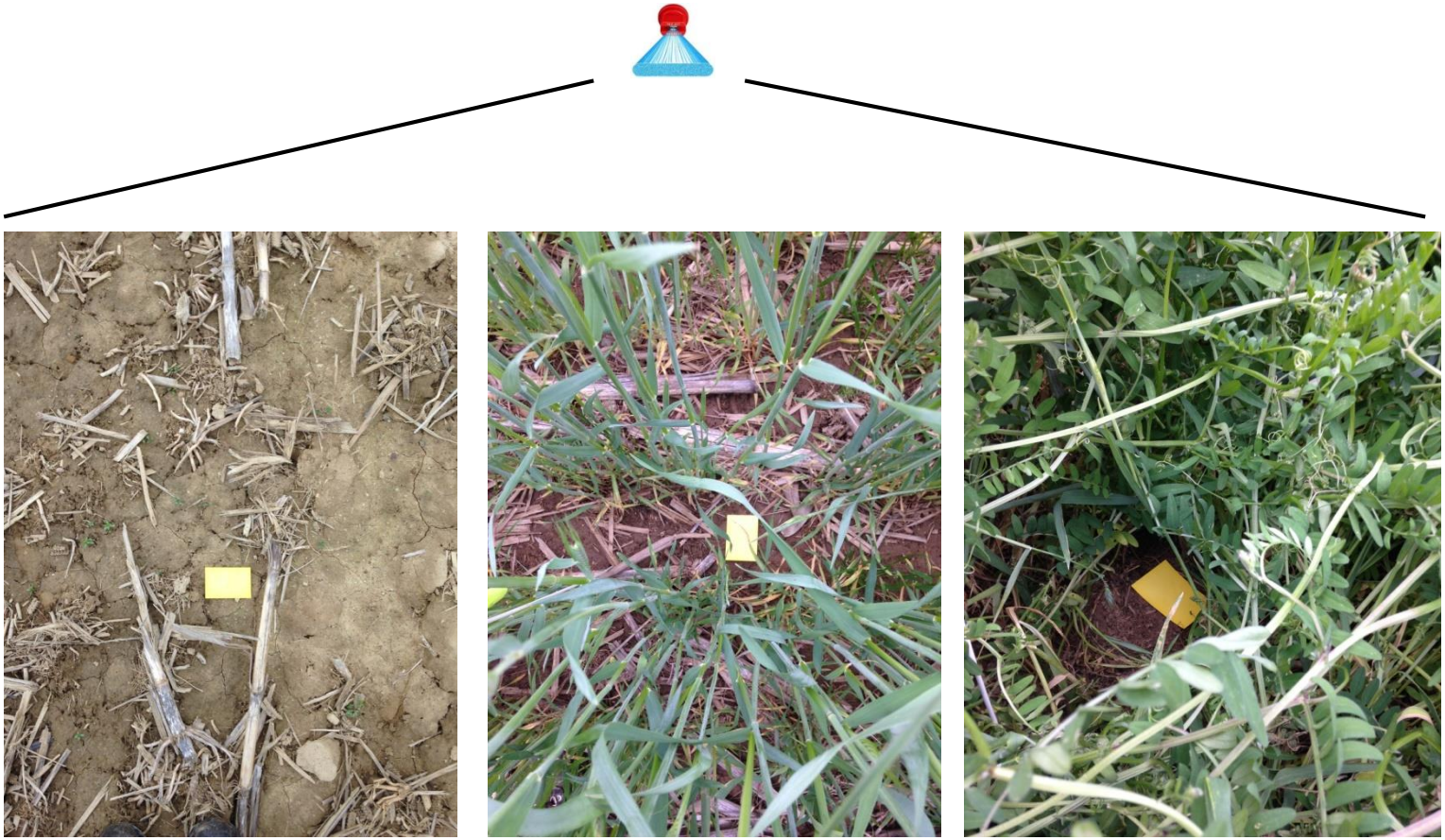
Can Cover Crops Impact Residual Herbicide Efficacy?



No Cover | Rye | Rye + Vetch

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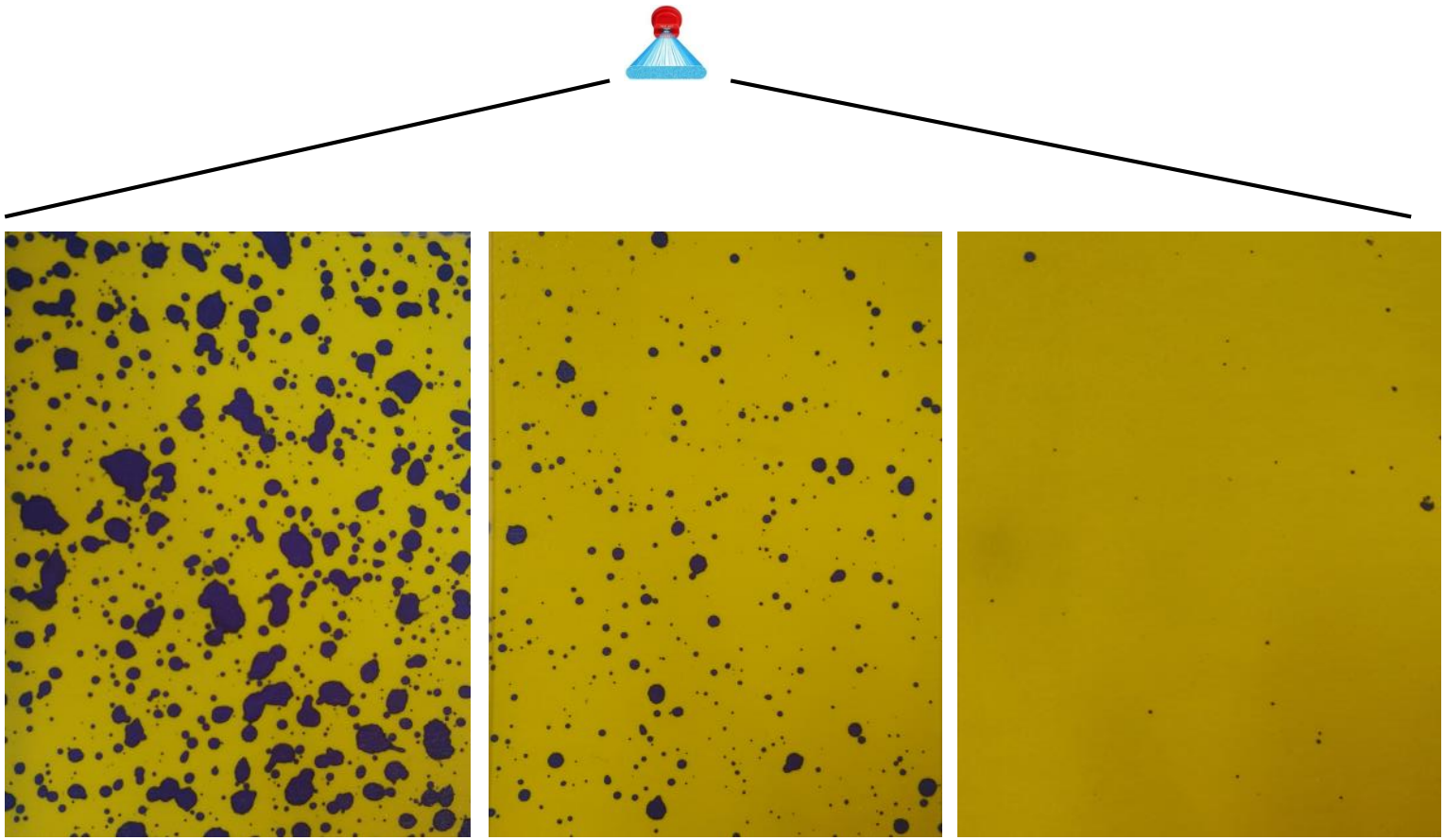

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Residual and Contact Type Herbicides

- May lose performance if applying to large/mature cover crops
- Particular problem for hidden weeds or for soil applied herbicide distribution
- Can you see the soil from above the canopy?
- Systemic herbicides less problematic than contact for control of emerged weeds – Can nozzle selection influence performance?
- Apply residual herbicides after burndown if large/dense cover crops are present

Does rye termination timing influence corn herbicide injury potential?

- No definitive PGR herbicide injury observed in our study
- Rainfall and temperature pattern is likely very important

2,4-D burndown - Corn

- PREPLANT – Planting of corn must be delayed a minimum of 7 days after application at rates up to 1 pint and 14 days at rates from 1 to 2 pts. Planting sooner may result in unacceptable crop injury.
- PRE – Apply after corn is planted but before emergence. Seed furrow must be completely closed at application or severe crop injury may result

Dicamba (Clarity or Banvel) burndown - Corn

- Direct contact of Clarity with corn seed must be avoided. If corn seeds are less than 1.5 inches below the soil surface, delay application until corn has emerged.
- PREPLANT and PRE – Apply 16 fl. oz. on medium or fine-textured soils with ≥ 2.5% OM. Use 8 fl. oz. on soils with less than 2.5% OM
- In reduced till, do not apply PRE to soils with less than 2.5% OM until after corn emergence

Special Considerations for Planting Green

- Glyphosate – cover seed and use Roundup Ready if crop emerging
- Paraquat – cover seed and apply before crop emergence
- PGR herbicides - Some injury potential – timing important
  - Enlist (2,4-D) and Xtend (dicamba) Technologies could provide safer PGR-based tank-mixes for burndown
- Other herbicides – Product specific – could be preplant or crop emergence issues

Questions?

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